Effect of Closing Hillsides Afforestation on Population Diversity

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Abstract A logaritmic series distribution model was used to evaluate the index of population diversity (α value) in *Quercus mongolica* forest in Zhanguangcai Mountains, Heilongjiang, Northeastern China. The α value went up from 1.07 to 4.46 ~ 6.98, after closing hillsides for 20 years. The spatial distribution of the α value was calculated among the hill slopes. The results were as follows: middle of hill > bottom of hill > top of hill.

Key words: Diversity, Secondary forest, Closing hillsides, Afforestation

Sample Site

The sample sites were set up in Xiangyang Forest Farm, Wuchang County of Heilongjiang province, belonging to the branch of Zhangguangcai Mountains of Changbai Mountains. They have limited forest areas, destroyed seriously by people. Even in neighbor forest farm, the forest vegetation nearly disappeared, and brush-wood, barren mountain and soil and water loss appeared. Therefore, it is responsible for us to begin to take closing hillsides and to make the forest recover naturally. For the aim of our investigation, we want to know the changes of population diversity after closing hillsides for 20 years.

Methods

Investigation methods

We sampled respectively from the region closed and not closed hillside. The size of plots along the trend of hills and the size of plots was 20 × 20m^2. The investigation items included trees species name, location, diameter at breast height, abundance, degree of coverage and frequency. The location of sample sites were: A, barren brush-wood not closed hillsides; B, the bottom of hill closed hillsides; C, the middle of hill closed; D, the top smooth place of hill.

Calculation methods

Diversity contains ecosystem diversity, community diversity, population diversity and species diversity. For population in community, there are several methods to measure species diversity and abundance in community, and the logarithmic series distribution model is one of them. Wills (1992), Fisher (1943) and so on, many scholars have tried to find good methods of measuring populations diversity objectively since 1920. Fisher summarized the logarithmic series distribution model applied by Numata (1943, 1969), Magurran (1988) and Ma Ke-ping (1994). The results indicated that this method was handy and effective for measuring populations diversity in community.

The meaning of logarithmic series distribution model was that the number of population with different individuals in the same community was up to the logarithmic distribution. It is:

$$\alpha x,\ \alpha x^2/2,\ \alpha x^3/2,\ \ldots\ldots \alpha x^n/n,$$

$$S_n = \alpha x^n/n,\ x = N/(\alpha + N) \qquad (1)$$

Where: S_n is the number of population with n individuals; N is the sum of individuals in different populations; α is the index of diversity or the index of divers. The number of all species in community is:

$$S = \sum_{n=1}^{\infty} S_n = -\lg(1-x) \qquad (2)$$

We got the result below from formula (1) and (2):

$$S = \alpha \lg(1 + N/\alpha) \qquad (3)$$

When $N \gg \alpha$

$$S = \alpha \lg N - \alpha \lg \alpha$$

solve this equation, we get the formula below:

$$\lg N/S \approx \lg N/\alpha \qquad (4)$$

In order to conveniently calculate, Fisher (1943) made a Table (Table 1) of getting lg N/α from lg N/S. It became easy to calculate α value. For example, if the number of individuals in community (N) is 645, the number of populations (S) is 23, the index of diversity of this community is 4.65.

Results and Analysis

Using the model, the indexes of diversity for four plots (A, B, C, D) were got (Table 2). Compared with the earlier work, N in Table 2 only represented woody plants, S was modified according to N and high trees in Table 2

referred to above 3 m height or 5 cm at root diameter.

Table 1. The results of lg N/α by lg N/S (Fisher 1943)

lg N/S	0	1	2	3	4	5	6	7	8	9
0.4	0.611211	63084	65023	66939	68832	70701	72551	74382	76195	77990
0.5	0.79766	81526	83271	85002	86717	88417	90105	91779	93442	95092
0.6	0.96730	98356	99973	1.01579	03174	04759	06335	07902	09460	11010
0.7	1.12550	14083	15607	17124	18634	20136	21631	23120	24602	26077
0.8	1.27546	29008	30465	31916	33361	34801	36234	37663	39087	40506
0.9	1.41920	43329	44733	46133	47528	48919	50305	51688	53066	54440
1.0	1.55810	57177	58539	59898	61254	62605	63954	65299	66640	67979
1.1	1.69314	70646	71975	73301	74623	75943	77261	78575	79886	81195
1.2	1.82501	83805	85106	86404	87700	88994	90285	91574	92860	94144
1.3	1.95426	96706	97984	99259	2.00532	01804	03073	04340	05605	06869
1.4	2.08130	09389	10647	11902	13156	14409	15659	16908	18155	19400
1.5	2.20644	21886	23126	24365	25602	26838	28072	29305	30536	31766
1.6	2.32994	34211	35446	36670	37893	39114	40334	41553	42770	43986
1.7	2.45201	46414	47627	48838	50048	51256	52464	53670	54875	56079
1.8	2.57282	58484	59684	60884	62083	63280	64476	65672	66866	68059
1.9	2.69252	70443	71633	72822	74011	75198	67385	77570	78755	79939
2.0	2.81121	82303	83484	84664	85843	87022	88199	89376	90552	91727
2.1	2.92901	94075	95247	96419	97590	98760	99930	3.01099	02267	03434
2.2	3.04600	05766	06931	08095	09259	10422	11584	12745	13906	15066
2.3	3.16225	17384	18542	19699	20856	22012	23168	24323	25477	26630
2.4	3.27783	28936	30087	31238	32389	33539	34688	35837	36985	38133
2.5	3.39280	40426	41572	42717	43862	45006	46150	47293	48436	49578
2.6	3.50719	51860	53001	54141	55280	56419	57558	58696	59833	60970
2.7	3.62106	63242	64378	65513	66648	67782	68915	70048	71181	72313
2.8	3.73445	74577	75707	76838	77968	79097	80227	81355	82484	83611
2.9	3.84739	85688	86992	88119	89244	90370	91495	92619	93743	94867
3.0	3.95991	97114	98236	99358	4.00480	01602	02723	03843	04964	06084
3.1	4.07203	08322	09441	10560	11678	12795	13913	15030	16147	17263
3.2	4.18379	19494	20610	21725	22839	23954	25068	26181	27295	28408
3.3	4.29520	30632	31744	32856	33967	35079	36189	37300	38410	39520
3.4	4.40629	41738	42847	43956	45064	46172	47280	48387	49494	50601
3.5	4.51707	52814	53920	55025	56131	57236	58340	59445	60549	61653

Table 2. Population diversity during closing hillsides

Site		S	N	Community	Investigate range	Area	α
	A	6	290	Brushy -oak forest	Woody-plants	20 × 20m^2	1.07
		2	48		High-trees	20 × 20m^2	1.03
	B	20	122	Deciduous broad-leaved forest of oak in the lower of hill	Woody-plants	20 × 20m^2	6.80
Zhangguang-cai		10	82		High-trees	20 × 20m^2	2.92
Mountains							
	C	24	210	Deciduous broad-leaved forest of oak in the middle of hill	Woody-plants	20 × 20m^2	6.98
		8	62		High-trees	20 × 20m^2	2.45
	D	19	312	Deciduous broad-leaved forest of oak at the top of hill	Woody-plants	20 × 20m^2	4.46
		7	80		High-trees	20 × 20m^2	1.85
a) Xiaoxingan Mountains		28	1285	Spruce-Korean-pine forest	Woody-plants	1ha	14.1
		13	212		High-trees	1ha	9.5
b) East Siberia		2	24	Larch forest	Above 10 m height	20 × 20m^2	0.2

Note: a) from Gordeev (1956), b) from Kira (1952)

From Table 2, the α value of population diversity for woody-plant was very low (1.07) for plot A before closed hillsides. The value equal to that of sand dune along a coast, or higher a little than that of slash along a coast, or higher a little than that of slash with salt

After closing hillsides, there were quite high α value for all the plots, the highest value is 6.98 in the middle of hill for plot C. And even the lowest value was up to 4.46 at the top of hill for plot D. Through the calculating for high tree, we got similar regularity. The reason of producing the regularity was that other populations invaded after closed hillsides. At first, heliopytes invaded, such as *Populus davidiana, Betula platyphylla* and so on. Then neutrophilous tree also invaded such as *Acer mono, Tilia amurensis* and *Phellodendron amurense*. Finally the brushy tree, *Acanthopanax senticosus, Corylus heterophylla* and *Sambucus coreana* also increased. These increased the population diversity in community.

Conclusions

The diversity index of population in community went up from 1.07 to 6.98, after closed hillsides. Although the value was lower than that for deciduous broad-leaved forest of Korean pine in Xiaoxingan Mountain, there were a large changes for abundance of populations in community

Another result showed there were difference in populations diversity at different slope location of hill, after the recovery vegetation through closing hillsides. The populations diversity is the highest at the middle of hill, the second at the bottom of hill, and the lowest at the top of hill.

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